

D. G.  
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METHOD FOR CORRECTING DEFECTS ON COLOR FILTER

BACKGROUND OF THE INVENTION

The present invention relates to a method for  
5 correcting protruding defects or white or black defects on  
a color filter, which occur during a process to manufacture  
a color filter for liquid crystal display apparatus.

Referring to Fig. 6, description will be given below  
on an example of a method for manufacturing a color filter.

10 On a transparent substrate 2 such as a glass plate, a  
light-shielding layer BM comprising striped pattern with  
line width of 20  $\mu\text{m}$ , pitch of 80  $\mu\text{m}$ , and film thickness of  
about 0.5  $\mu\text{m}$  is formed by screen printing. Next, on the  
light-shielding layer, a red colorant sensitive material R  
15 is coated. Then, a photo mask is placed and light  
exposure is performed. Next, a green pattern layer and a  
blue pattern layer are formed by the same procedure. Both  
longitudinal sides of each color pattern layer are  
overlapped on the light-shielding layer BM for a length of  
20 about 10  $\mu\text{m}$ , and the film thickness is about 2  $\mu\text{m}$ . Next,  
with the purpose of achieving physico-chemical protection,  
and of evenly adjusting and flattening the surface, a  
photo-curing resin is coated on the color pattern layer,  
and a protective film layer OP is formed in film thickness  
25 of about 2 - 3  $\mu\text{m}$ . Further, a film of indium tin oxide  
(ITO) is formed on the protective layer by vacuum film  
forming method, and electrode pattern is fabricated by mask  
deposition method, etching method, etc., and a transparent

electrode layer is formed to prepare a color filter.

In the process to manufacture the color filter as described above, foreign objects "a" such as dust are intermingled in the coating process to coat color sensitive material as shown in Fig. 6. If these objects remain on the color pattern layers R, G or B or foreign objects such as dust are attached on the surface of the color pattern layer, protruding defects "b" may be formed on the portions corresponding to the foreign objects such as dust when the protective layer OP is formed on the color pattern layer. Also, when dust is attached on the photomask, white defects "c" may occur on the color pattern layer or black defects may be generated on the light-shielding layer BM. Such defects may impair orientation of liquid crystals in liquid crystal cells, which are provided on the surface of the color filter, or may lead to defects in the images taken or displayed, and the products produced using the color filter may become defective. In the past, as described in JP-A-3-274504 or JP-A-9-184910, methods have been proposed to coat a colorant sensitive material after cutting the defective portion off and to remove it using the laser beam in order to correct the above defects.

#### SUMMARY OF THE INVENTION

However, according to the conventional method for correcting defects as described above, it is difficult to fill ink to corners when the corrective ink is dropped to the upper surface because almost the entire region of

picture element is cut in rectangular shape, and void patches or unevenly colored portions are likely to occur. Also, the quantity of the colorant to be removed is higher than the case when only the portion near the defects are cut off. As a result, colorant materials are splashed to the surrounding regions, and these may cause new defects. Further, in case the hue of the corrective ink is different by approximately one picture element from the hue of colorant picture element, defects are very likely to occur due to color difference. As a result, the percentage of acceptable products after correction may be low.

To solve the above problems, it is an object of the present invention to provide a method for correcting defects on a color filter, by which it is possible to correct all of protruding defects, white defects and black defects, which are generated in the process to manufacture color filter and to extensively improve the percentage of high quality products.

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To attain the above object, the invention of claim 1 provides a method for correcting defects on a color filter, which comprises the steps of setting a diameter of a laser beam in a circular correcting region including defective portion, or more preferably, in a circular correcting region comprising a circle which circumscribes the defective portion in order to ensure better permeation of liquid and better diffusion, and to prevent uneven coloring due to insufficient flow of the liquid when the defective portion on the color filter is removed by irradiation of

the laser beam, dropping a corrective ink to upper surface of the circular correcting region by an ink jet unit so that the ink is formed in spherical shape after the circular correcting region has been removed, and hardening and shrinking the corrective ink by an ink hardener thereafter so that variation of film thickness in the circular correcting region can be controlled within 0.1  $\mu$ m.

The invention according to claim 2 provides a method for correcting defects on a color filter, said method comprising the step of setting a diameter of a laser beam on a circular correcting region including defective portion when the defective portion on the color filter is removed by irradiation of the laser beam, and depositing a metal film of more than 1000 angstrom in thickness by laser CVD method on the circular correcting region after the circular correcting region has been removed so that back light can be completely shielded.

According to the present invention, it is possible to easily correct all of protruding defects, white defects and black defects caused in the process for manufacturing the color filter, and also to extensively improve the percentage of high quality products. Further, according to the invention of claim 1, ink can be dropped by selecting ink color depending on the defective region by the ink jet unit. For example, in case the correcting region is a green pattern layer, a green corrective ink can be dropped. As a result, defects on the green pattern portion can be easily corrected without resulting in uneven

~~coloring.~~

#### BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a block diagram to explain an example of a  
5 method for correcting defects on a color filter according  
to the present invention;

Fig. 2 is a drawing to explain setting of a diameter  
of laser beam in the arrangement shown in Fig. 1;

*Figs. 2(A) - 2(C) represent*

*Fig. 3 represents drawings to explain Example 1 shown*  
10 in Fig. 1;

*Figs. 4(A) - 4(D) represent*

*Fig. 4 represents drawings to explain Example 2 shown*  
15 in Fig. 1;

*Figs. 5(A) - 5(C) represent*

*Fig. 5 represents drawings to explain a comparative*  
example shown in Fig. 1; and

Fig. 6 is an enlarged sectional view to explain a  
defect on a color filter.

#### DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Description will be given below on embodiments of the  
20 present invention referring to the drawings. Fig. 1 is a  
block diagram to explain an example of a method for  
correcting defects on a color filter according to the  
present invention.

In Fig. 1, a substrate 2, which has a color pattern  
25 layer as described above formed on it, is placed on an XY $\theta$   
stage (substrate moving stage) 1. This XY $\theta$  stage can be  
moved along XY plane and at a tilt angle  $\theta$  by a driving  
mechanism 3. A defect detecting unit 4 is a device for

checking defects on a color filter as described above. A  
CCD camera 5 takes an image of the substrate 2 via an  
objective lens 6, a semitransparent mirror 7 and an image  
forming lens 8. The data of the image thus taken is sent  
5 to an image processing unit 9, where the data is binarized  
with a preset threshold, and a defective portion on the  
substrate 2 is extracted. The extracted defect  
information is displayed on a display 10 for confirmation,  
and it is sent to an arithmetic unit 11.

10 A laser irradiation unit 12 irradiates a laser beam to  
the defective portion detected by the defect detecting unit  
and it is used to remove substances which are present  
within that region. The laser beam is emitted from a UV  
laser oscillator 13 (YAG laser) with output of 15 mJ or  
15 more (wavelength: 1067 nm) or with output of 2 mJ or more  
(wavelength: 533.5 nm), and irradiation energy density of  
the laser beam is increased or decreased by a density  
adjuster 14. The diameter of the laser beam is enlarged  
by a diameter enlarger 15, and intensity of the laser beam  
20 is equalized, and it enters an opening adjuster 17 via a  
mirror 16. The opening adjuster 17 is provided with a  
plurality of moving plates around the opening. By moving  
the moving plates using a driving mechanism 18, the  
diameter of the opening is adjusted, and the diameter of  
25 the laser beam can be adjusted to the value as desired.  
That is, as shown in Fig. 2, when a defective portion D is  
picked up on a picture element I of a CCD camera, a  
diameter "r" of the laser beam is set within a circular

correcting region M, which comprises a circle  
circumscribing the defective portion D, and its center is  
used as a position information of the defective portion D.  
The circular correcting region M may be a circle, which  
5 includes the defective portion D. The diameter "r" can be  
changed within the range of 50 to 150  $\mu$ m. After the  
diameter of the laser beam has been adjusted to a desired  
value by the opening adjuster 17, the laser beam is  
protruding to the substrate 2 positioned on the XY $\theta$  stage  
10 1 via a mirror 19, an image forming lens 20, the  
semitransparent mirror 7 and the objective lens 6.

A defect correcting unit 21 is a device to place and  
fill a pattern layer into a portion, from where the  
substances have been removed by the laser irradiating unit  
15 12, and it is provided with an ink discharge unit 22, a  
driving circuit 23 for driving the ink discharge unit and  
an ink hardener 24. As the ink discharge unit 22, a  
dispenser or an ink jet device may be used. As the method  
for discharging from the dispenser, a continuous discharge  
20 method for continuously discharging the ink or an  
intermittent discharge method for intermittently  
discharging the ink after ink drops are prepared may be  
used. As the ink jet unit, there are two types:  
continuous type and on-demand type. The former is to  
25 apply an electric field while ink is continuously injected,  
and ink is collected on a capture dish so that ink is not  
coated on the substrate of the color filter. According to  
the latter, the color filter substrate is moved, and ink

discharge is turned on or off, depending on the position of the substrate. As the ink discharge unit 22 as described above, it is preferable to use an ink jet unit. Other methods are that corrective inks can also be dropped by laser thermo-fusible transfer method, needle painting method, and so on. In the following, description will be given by taking an example on the ink jet unit.

The ink jet unit 22 is a device to drop corrective ink in four colors of red, green, blue and black. The corrective ink is preferably an ink made of thermo-curing resin or UV-curing resin with higher surface tension. The ink hardener 24 comprises a heating block or a UV-irradiation spot light source. It is designed in such manner that the ink jet unit 22 and the ink hardener 24 can be moved toward the substrate 2 by a lift mechanism (not shown).

The arithmetic unit 11 transmits an information, which indicates shape of the defective portion and its position to the driving mechanism 18, and drives the opening adjuster 17 to change the diameter of the laser beam. At the same time, it drives the XYθ stage 1 and determines irradiating position of the laser beam. Also, it transmits signals to the UV laser oscillator 13 and the density adjuster 14 and controls irradiation time, number or times of irradiation, and irradiation energy density. Signals of ink color and ink drop quantity are sent to the driving circuit 23, and the ink jet unit 22 is controlled.

Next, description will be given on Examples 1 and 2

and comparative example of this embodiment. First, Example 1 will be described referring to Fig. 3.

Fig. 3 (A) shows a condition where the circular correcting region M including the defective portion of a green pattern layer G is removed by the laser beam. In this example, line width of a light-shielding layer BM is 20  $\mu\text{m}$ , BM spacing is 80  $\mu\text{m}$ , film thickness of a colored layer RGB is 1.4  $\mu\text{m}$ , and diameter of the circular correcting region M is 55  $\mu\text{m}$ . Next, green corrective ink G' is dropped to the circular correcting region M by the ink jet unit 22 as shown in Fig. 3 (B). As the green corrective ink G', thermo-curing resin or UV-curing resin is used.

● The following materials were used as the thermo-curing resin:

Binder resin: Copolymer of benzyl methacrylate and glycidyl methacrylate

Multifunctional epoxy resin:

Cresol novolak type epoxy resin

Polyvalent carboxylic acid: Trimellitic acid

Solvent: Propylene glycol monomethylether acetate

G pigment: C.I.No. Pigment Green 36

Y pigment: C.I.No. Pigment Yellow 150

Dispersant: Solsperse 24000 (manufactured by Avicia)

● A pigment dispersion composition having the following components was used as UV-curing resin:

Binder resin: Copolymer of methacrylic acid and  
benzyl methacrylate

Multifunctional monomer:

Trimethylolpropane triacrylate

5 Photopolymerization initiator:

Irgacure 907 (manufactured by Ciba  
Specialty Chemicals)

Solvent: Ethoxyethyl propionate

G pigment: C.I.No. Pigment Green 36

10 Y pigment: C.I.No. Pigment Yellow 150

Dispersant: Solsperse 24000 (manufactured by  
Avicia)

Discharge quantity (volume) of this ink was 4 drops at  
the rate of 20 PI/drop. That is, ink drops of 80 PI were  
15 dropped so that the ink is formed in spherical shape on  
upper surface of the circular correcting region (Fig. 3  
(B)). Finally, when the corrective ink G' was hardened  
using the ink hardener 24, the corrective ink G' was shrunk  
as shown in Fig. 3 (C), and the circular correcting region  
20 M was filled and corrected to be flush. Thus, it is  
possible to equalize variation in film thickness to 0.1  $\mu\text{m}$ ,  
and unevenness of color can also be corrected almost to the  
level suitable for practical use.

In case of thermo-curing resin, when the corrective  
25 ink G' is hardened, baking was performed at 220°C for 10  
minutes on the heating block. By this heating, the  
spherically swollen form of ink by 5  $\mu\text{m}$  higher than the  
upper surface of the surrounding portion after ink dropping

was reduced to a form of a concave lens by  $0.05\mu\text{m}$  lower than the upper surface of the surrounding portion. In case of UV-curing resin, ultraviolet ray was irradiated by spot irradiation of  $1000\text{ mJ}/\text{cm}^2$ , and baking was performed at  $200^\circ\text{C}$  for 30 minutes on the heating block. By this heating, the spherically swollen form of ink by  $5\mu\text{m}$  higher than the upper surface of the surrounding portion was turned to a form of a convex lens which was by  $0.09\mu\text{m}$  higher than the upper surface of the surrounding portion.

Next, Example 2 will be described referring to Fig. 4. Fig. 4 (A) shows a red pattern layer R. A protruding defective portion D is present where the size of picture element is  $100 \times 300\mu\text{m}$ , and film thickness is  $1\mu\text{m}$ . Fig. 4 (B) shows a condition where the circular correcting region M including the defective portion D is removed by the laser beam. Diameter of the circular correcting region M is  $60\mu\text{m}$ . Next, red corrective ink R' is dropped to the circular correcting region M by the ink jet unit 22 as shown in Fig. 4 (C). As the red corrective ink R', thermo-curing resin is used.

● The following substances were used as the thermo-curing resin:

Binder resin: Copolymer of benzyl methacrylate and glycidyl methacrylate

Multifunctional epoxy resin:

Cresol novolak type epoxy resin

Polyvalent carboxylic acid:

Trimellitic acid

S lvent: Propylene glyc 1 monomethylether  
acetate

R pigment: C.I.No. Pigment Red 254

Y pigment: C.I.No. Pigment Yellow 139

5 Dispersant: Solsperse 24000 (manufactured by  
Avicia)

Discharge quantity (volume) of this ink was 4 drops at  
the rate of 20 PI/drop. That is, ink drops of 80 PI were  
dropped, and the ink was turned to a spherically swollen  
10 form by 5  $\mu$ m higher than the upper surface of the circular  
correcting region M (Fig. 4 (C)). Finally, baking was  
performed at 220°C for 10 minutes on the heating block. By  
this heating, a spherically swollen portion by 5  $\mu$ m higher  
than the upper surface of the surrounding portion formed  
15 after dropping of the ink was turned to a form of a concave  
lens by 0.9  $\mu$ m lower than the upper surface of the  
surrounding portion (Fig. 4 (D)). Because the corrective  
ink having the same hue as the red pattern layer R was  
filled, there was almost no difference of color on the  
20 corrected portion.

Next, the comparative example will be described  
referring to Fig. 5. In the same manner as in Example 2  
shown in Fig. 4 (A), correction was carried out on the red  
pattern layer R where a protruding defective portion D was  
25 present with size of the picture element 100 x 300  $\mu$ m and  
film thickness of 1  $\mu$ m. As shown in Fig. 5 (A), a mask  
with rectangular opening was placed, and a correcting  
region M' including the defective portion D was removed by

the laser beam. The size of the portion to be removed was 100 x 300  $\mu$ m, and this approximately corresponded to one picture element. Next, to the correcting region M' of the portion to be removed, a red corrective ink R' which was  
5 the same corrective ink as in Example 2 was dropped by the same procedure as in Example 2. As shown in Fig. 5 (B), a portion not filled with ink (ink-lacking portion) X was generated at each of four corners of the rectangular correcting region M'. Next, when baking was carried out  
10 by the same procedure as in Example 2, a void portion C or unevenly colored portion C' due to insufficient film thickness was found as shown in Fig. 5 (C).

Next, description will be given on another embodiment of the present invention. In the above embodiment, the  
15 defect correcting unit 21 comprises an ink jet unit 22, a driving circuit 23, and an ink hardener 24. In the present embodiment, however, instead of the defect correcting unit, a device based on the laser CVD method is used, and a metal film of light-shielding film BM, which  
20 has chromium or tungsten as the main components such as  $\text{Cr}(\text{CO})_6$ ,  $\text{W}(\text{CO})_6$ , is deposited by vacuum evaporation in thickness of 1000 angstrom or more. According to this method, similarly to the case of the defect correcting unit 21, the substances in the circular correcting region M  
25 detected by the information transmitted from the arithmetic unit 11 are removed, and the metal film of the light-shielding film BM is deposited on the circular correcting region M. As a result, back light can be completely

shielded. Even when the circular correcting region is a color pattern layer, the metal film of the light-shielding film BM is deposited. No problem occurs in the produced color filter, and not only black defects but also

5 protruding defects or white defects on the color pattern layer can be corrected. When the device based on the laser CVD method is used, the thickness of the metal film to be deposited can be adjusted, and it is possible to form a color pattern layer with no variation in film thickness.